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The PPT Program contains research activities designed to address knowledge gaps and improve existing technologies to reduce exposure to injury hazards. Specific projects related to this Goal 3 are performed across the NIOSH organization; several NIOSH divisions participate. The projects are conducted primarily as a part of the activities of other NIOSH sector and cross-sector programs, but are directly supporting the development of advanced PPT.

This strategic goal emphasizes four areas:

- warning devices for fire services,
- PPT to reduce hearing loss exposure,
- PPT to reduce occupational fall exposures, and
- vibration isolation gloves to reduce hand-arm vibration syndrome.

PPT Program effort directed towards the objective to develop and evaluate warning devices is discussed in detail below, as section 5.1.

As noted earlier, the projects and related activities involving the last three of these areas have been (or are presently being) reviewed as part of their parent programs within the framework of the National Academies Evaluation of NIOSH Research Programs. Description of the work performed for these three areas is included in this Evidence Package as Appendix D (Strategic Goal 3: Reduce Exposure to Injury hazards). It is included for completeness and to indicate the comprehensive nature of the PPT Program.

Occupational hearing loss is damage to the inner ear from noise or vibrations due to certain types of jobs or entertainment.[1] While hearing loss may be classified as a work related illness,[2, 3] the PPT Program includes hearing loss among occupational injuries described in this evidence package since hearing protectors reduce exposure to noise hazards associated with workplace injuries resulting from excessive noise.

The PPT Program initiatives to reduce exposure to occupational injuries in the fire services have emphasized the use of warning and personal location devices, the use of which by fire and emergency services personnel has increased in the past decade. PPT Program initiatives include active participation in National Fire Protection Association (NFPA) committees and research and evaluation activities to address the issues.

As with its other goals, the PPT Program takes four tactical approaches for accomplishing this goal:

- Conduct research on personal injury protection technologies.
- Develop standards for personal injury protective equipment.
- Evaluate personal injury protective equipment.
- Conduct outreach programs for optimal use and acceptance of personal injury protective equipment by workers.

5.1 Develop and Evaluate Warning Devices for Fire Services. [Back to the Table of Contents](#)

Issue

The use of warning and personal location devices by fire and emergency services personnel has increased in the past decade. Becoming lost or trapped in a fire situation is the second leading cause of death accounting for approximately 22 lives lost annually. Injuries due to burns, asphyxiation, or respiratory distress, usually occurring when a firefighter is trapped in a burning building, is the second leading cause of injury accounting for approximately 17,000 injuries.[4]

The Personal Alert Safety System (PASS) and other warning devices should be enhanced to ensure technical advances are incorporated to minimize firefighter exposure to injury hazards. The technology desired by the fire service stakeholders of the PPT Program is a location and tracking system that does not require any previously installed wiring or equipment in the building. The primary goal is to provide tracking and position location information in real-time.

Background

On December 20, 2004, a 24-year-old male career probationary firefighter (the victim) died after he became separated from a fire-attack team at a two-alarm, single-story, residential structure fire.[5] The fire-attack team and a search and rescue team entered the structure through the front entrance. After approximately 4 minutes, the crews the victim was operating with had to perform an emergency evacuation from the structure due to intensifying, uncontrollable fire conditions. Immediately after the evacuation, a Personnel Accountability Report (PAR) was called. Soon after, the crews realized that the victim was missing. The Rapid Intervention Team (RIT) attempted to search for the victim, but was unable to make entry due to the fire conditions. The victim was found approximately 15 minutes after the PAR, about 15 feet from the point of entry. The victim was pronounced dead on-scene by the county medical examiner.[5]

Firefighters are provided with PASS which alarms audibly as a means to identify and locate firefighters who have become physically incapacitated in environments with obscured vision. Some PASS systems are integrated into the Self-Contained Breathing Apparatus (SCBA) used by the firefighters. These SCBA-integrated PASS systems are automatically activated when the SCBA breathing air is turned on.

Data on the temperatures to which firefighters are exposed during internal or structural firefighting operations are needed to help create proper mission performance requirements for firefighter Personal Protective Equipment (PPE). The National Institute of Standards and Technology (NIST) has developed extensive data on fire temperatures but has limited information on firefighter thermal exposures. Without this information, the desire to harden the PPE against a much greater level of heat exposure and thermal loading may actually add to the overall danger facing these workers.

Performing their duties at an incident scene can adversely affect proper functioning of firefighters' PPE by exposure to high temperatures. Existing NFPA standards attempt to address this issue by specifying ambient temperature extremes at which the PPE must continue to

perform. Improvements in the thermal/flame protection required in firefighter protective ensembles now affords short duration protection from burns in the 350°F to 500°F temperature range. More robust protective ensembles would permit penetration to fire areas in which firefighters would not have been able to venture without the PPE.

The National Memorial Institute for the Prevention of Terrorism (MIPT) identified the need to develop technology that would provide incident commanders knowledge about the location of personnel and equipment in an incident area. A key goal is to identify and locate an individual within 3 meters in any direction and under any condition with a range of at least 1,000 feet. The objective is to provide reliable, lightweight, cost-effective, and embedded absolute three dimensional positional locations and communication to firefighters, police officers, and emergency medical services.[6]

Approach

The PPT Program expedited efforts to gather available resources after the terrorist attacks on the World Trade Center (WTC) and the Pentagon on September 11, 2001. Several months before these incidents, the National Personal Protective Technology Laboratory (NPPTL) was formed and was assigned the responsibility for the PPT Program. NPPTL leadership quickly funded the RAND Corporation to assist it in developing strategies for protecting emergency responders. A four-part series of publications resulted.[4, 7-9]

The first effort funded was a NIOSH/RAND PPT Conference held in New York City. The PPT Program sponsored this conference to obtain first-hand knowledge from responders and experts regarding the PPE and PPT needs evident as a result of the 9/11 terrorist attacks. The International Association of Firefighters (IAFF) provided an overview of concerns related to domestic defense and concern regarding the ability of PPE to meet requirements over time due to wear and maintenance. The New York City Fire Department explained that burn injuries were reduced from previous events; however, firefighters using new equipment experienced increased heat exhaustion. It was concluded that more protection is not necessarily better for the responder.

The second report prepared by RAND helped to define the technology needs and research priorities for personal protection for emergency responders. At the same time, two other studies were funded by the PPT Program. Pennsylvania State University was funded to compile documents distributed by the WTC and Pentagon that addressed the selection, use, and maintenance of PPE. The documents were categorized into specific focus areas and defined subsets to obtain PPE information and guidelines made available to first responders.[10] The intent was to identify any gaps where the PPT Program should focus its future efforts. More than 190 individuals with an interest in the WTC and Pentagon rescue sites were identified and contacted with a request to provide copies of written material distributed or intended to be distributed at each of the two sites. More than 200 PPE guidelines were identified, analyzed and compiled. The compilation was delivered to the PPT Program in May 2003.

Another study was prepared as a result of a contract awarded to the Occupational Health and Safety Division of the IAFF[11] to review modern fire services hazards and protection needs.

136 Reports were prepared that provided insight into the needs of the fire services, including the need
137 for a firefighter locator device. They were delivered to the PPT Program in October 2003.[12]
138

139 In response to these various findings, a contract was awarded to Carnegie Mellon University to
140 develop a personal location device for emergency responders. The PPT Program provided
141 funding to support an ongoing effort with the United States Army to develop a wearable system
142 for human localization. The system is designed to track a user's position and mode of motion
143 under a variety of conditions. The device makes use of global positioning system (GPS) when
144 possible, but also includes sensors on the user's body to track motion using kinematic models of
145 walking.
146

147 The specific objective of the PPT Program participation was to enhance the ability to locate a
148 downed firefighter. The project began in 2002 and continued to 2005. A subsequent peer review
149 of the project's progress concluded that the technology resulting from 3 years of PPT Program
150 funding was demonstrated. However, other investigations pursuing competing technological
151 approaches were deemed more advanced, and PPT Program management decided to end the
152 contract effort.
153

154 PPT Program personnel continue to monitor the research efforts of others to develop a firefighter
155 location system. For example, a PPT Program scientist participated in the "Precision Indoor
156 Personnel Location and Tracking for Emergency Responders" workshop hosted by Worcester
157 Polytechnic Institute (WPI) in August 2006. The workshop, funded by National Institute for
158 Justice through a grant to WPI, was attended by more than 100 federal, academia, and responder
159 and manufacturer representatives.[13]
160

161 A Small Business Innovation Research (SBIR) research grant was awarded through the NIOSH
162 OEP in 2004 to develop a Bioelectronic Telemetry System for Fire Fighter Safety. The goal of
163 the research was to develop a monitoring system to transmit vital sign and environmental
164 parameter data from firefighters in a burning building to the safety officer or incident
165 commander on the outside. The work emphasized technology leveraging by integrating off-the-
166 shelf sensors into firefighter turn-out gear to measure the desired vital signs and environmental
167 parameters, designing appropriate electronics and processing for these sensors, developing robust
168 telemetry system for reliably transferring data from within a variety of structures, and designing
169 a user-interface which can be easily used by a fire safety officer. The objective is to provide data
170 to the incident commander to make decisions about when to rotate personnel to avoid
171 preventable injury and death.[14] The grant is a two phase effort that will deliver a prototype
172 system capable of monitoring several vital signs and detecting firefighter motion inside a
173 building. The final report will delivered to NIOSH after the August 2007 completion date.
174

175 In a parallel effort, the PPT Program conducted an analysis of Fire Fighter Fatality Injury
176 Investigation and Prevention Program (FFFIPP)[15] data contained in the PPT Program's
177 Certified Product Investigation Process (CPIP) database. It discovered that the victims' PASS
178 alarm signals were either not heard or barely audible. These discoveries were made during the
179 investigation of firefighter fatalities that occurred from 2001 to 2004. In several investigations
180 the PPT Program's post-incident evaluation of the equipment showed the PASS audible alarm
181 were functioning at ambient temperatures. One specific incident investigation by an independent

laboratory showed that the integrated PASS was not functioning as a result of a short circuit in the SCBA/PASS unit caused by melting of wiring harness insulation from heat and flame exposure.

Laboratory testing of PASS by the NIST Fire Research Division has shown that reductions in the PASS audible alarm signals can begin to occur at temperatures as low as 300° F (150° C). The NFPA Technical Committee on Electronic Safety Equipment included increased conditions of high temperature and water exposures under which PASS must perform in the 2007 Edition of NFPA 1982, Standard on Personal Alert Safety Systems (PASS).[16]

The PPT Program has recommended that to minimize the risk of similar occurrences, fire departments should:

- Consider using a backup manual PASS device in combination with SCBA equipped with integrated PASS devices,
- provide SCBA facepieces that are equipped with voice amplifiers for improved interior communications, and
- train firefighters on initiating emergency traffic (Mayday-Mayday) and manually activating their PASS alarms when they become lost, disoriented, or trapped.

In another effort, PPT Program researchers are conducting studies to understand thermal exposure of firefighters. The approaches to achieving the primary goal of reducing exposures to dermal and injury hazards under this project include:

- Conducting research to develop firefighter thermal exposure data which takes into account all sources of thermal flux,
- developing performance criteria and standards for PPE,
- conducting research to determine if it is possible to develop compact instrumentation that accurately characterizes firefighter thermal loading, and
- evaluating personal dermal protective equipment and technologies.

Compact instrumentation that accurately characterizes firefighter thermal loading might become the core of an even more important piece of equipment that could warn firefighters they are in danger of being overcome by heat.

Output and Transfer Highlights

NIOSH/RAND Personal Protective Technology Conference, New York City, NY Dec 9-11, 2001.[17]

Following the FFIIPP investigations and initial research studies, PPT Program personnel contributed significantly to the NFPA 1982 Standard updates. PPT Program personnel made recommendations to developmental testing for the NFPA 1982 Standard to eliminate the potential for PASS failure in the future. These contributions are useful for establishing proper mission criteria for any firefighter PPE standards.[16]

PPT Program personnel participated in two NFPA committee meetings and numerous teleconferences and face-to-face meetings to make recommendations about developmental testing for the NFPA 1982 Standard[16] to eliminate the potential for PASS failure in the future.

FFFIIP 2004 and 2005 Report regarding PASS failure.[5, 18]

R. Ramani et al., A compilation of personal protective equipment guidelines for emergency responders, Final Report 02NPTAT2201, May 2003[10]

Intermediate Outcomes

In late 2005, NFPA published an Alert notice [19] entitled "PASS alarm signals can fail at high temperatures" on the NFPA website advising emergency responders, especially firefighters, of the problem, and asking them to provide notification of any encountered problems to special email accounts at NIOSH's PPT Program and to the "third party" certification laboratory that granted NFPA certification standard approval. To date, no reports have been received by either certification authority.

The FFFIIP notified the NFPA Technical Committee on Electronic Safety Equipment of the determination of reduction of the PASS audible alarms. The Technical Committee increased the upper temperature and water resistance levels in the 2007 edition of the PASS as a result of the notification.

What's Next?

PPT Program personnel continue to participate in NFPA committee meetings to support future revisions to the NFPA 1982 Standard.[16] Support is also provided to the committee's efforts to develop performance requirements for the next generation of "wireless" PASS warning systems that direct a firefighter in distress to a base station outside the fire scene. This technology will permit a more rapid distress notice to the fire scene Incident Commander or Safety Officer and deployment of a RIT to rescue the fallen firefighter.

Future technologies will also permit the monitoring of firefighter location and physiological status such as heart rate, skin and internal body temperatures as warning signs of impending health hazards. Development of compact instrumentation that accurately characterizes firefighter thermal loading is anticipated.

List of Outputs

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